National Aeronautics and Space Administration

Summer of Innovation

Designing for Space Program Guide

Engineering the Missions and Tools for Space Exploration

4th – 9th grade

www.nasa.gov

Introduction

The goal of the NASA Summer of Innovation Designing for Space camp is to excite young minds and inspire student trainees toward future science, technology, engineering, and mathematics (STEM) pursuits. Raising trainee achievement in STEM pursuits begins by leading trainees on a journey of understanding through these highly engaging activities. The activities and experiences in this guide come from across NASA's vast collection of educational materials.

This themed camp outline provides examples of one-day, two-day, and weeklong engineering and science programs. Each day contains 6-8 hours of activities totaling more than 35 hours of instructional time. The camp template will assist you in developing an appropriate learning progression focusing on the concepts necessary to engage in learning about engineering. The activities scaffold to include cooperative learning, problem solving, critical thinking, and hands-on experiences. As each activity progresses, the conceptual challenges increase, offering trainees full immersion in the topics.

Intended Learning Experiences

Through the participation in these camps future scientists and engineers will have the opportunity to explore engineering and the design processes that support human and robotic missions throughout our solar system. From designing and testing a simple rover to designing a complex mission, trainees will learn how engineering combines creativity, science, math, and more to enable us to explore space. The learning experiences also anticipate that trainees will have the opportunity to:

- Describe the role of the engineering design process in space exploration
- Develop models of space exploration tools and missions
- Explore the various fields of engineering
- Discover the essential role of NASA in developing new technologies for space and Earth
- Demonstrate the role of journaling in engineering design
- Follow instructions and checklists in building
- Plan a design and follow through with a building plan
- Envision materials in a variety of new roles

Professional Development

Educator Professional Development (PD) experiences are available. Webinars, NASA Digital Learning Network (DLN) programs, training videos, and online meeting spaces will help you implement the program. We hope that you and your trainees have a memorable and successful experience implementing these activities.

Professional Development Resources

- The NASA Educator Online Network (NEON) is a great resource for STEM educators to share and learn about STEM topics. The Designing for Space camp hosts a group that will provide a place for sharing about the activities, additional resources, extension ideas, and support.
- Visit the Summer of Innovation homepage for an extensive catalog of news, media resources, educational materials and professional development resources.
- The Engineering Design Process video series will guide you through the steps in the Engineering Design Process.
- Visit the Summer of Innovation *Engineering Design Process* training module and the *Failure as a Concept* training module.

The Six E's

Each day or section of activities utilizes the 5-E Instructional Model. Included in this program guide is a sixth 'E' for Excite. This additional 'E' shows you how to incorporate NASA's unique information and resources to excite trainees with career connections, real world examples, spinoffs from NASA research, and more. Learn more about the 5-E Instructional Model.

$ Requires simple materials common in the classroom or relatively inexpensive to obtain.

$$ Requires purchasing unique materials such as poster board, duct tape, or hot glue guns.

$$$ Requires purchasing or building higher-cost items, though many are one-time purchases that may used for many trainees over several years.

Title	Overview	Time	Cost	Additional Resources
The title hyperlinks to the activity.	An overview describes the main concepts and strategies used in the lesson, activity, or demonstration.	The time listed includes time for an introduction, activity time, and conclusion time.	Please find this camp or the activity you are using in the Resource Repository for more information on costs and tips.	Suggested resources may include additional lesson plans, posters, images, or other learning support materials.

Engage: Question?

Icons may appear throughout the program	Journal
A computer symbol means you may need one or more computers or other technology, though alternatives are available. The pencil icon helps to identify the journal.	Journals are an optional element of your camp. Throughout the camp template, you will find reflective questions, ideas, and guidance in creating a journal. Journals also provide trainees with a unique souvenir of their experiences. Learn more about how scientists and engineers use journaling at NASA by watching this eClip video: Journaling in Space.

Journaling and the Design Process

Using a journal is a key element of the engineering design process and of the weeklong Designing for Space program. A journal is an essential tool that engineers use and in the camp, it is a tool for trainees to track their progress during the design process. A journal also provides instructors and opportunity for both formative and summative assessment of camper learning. Journals may be kept in analog or digital format depending on your camp objectives.

Throughout the camp outline, you will find several journal prompts that you can use. In addition, the following is a list of good journaling questions to use during an engineering challenge:

- Draw a sketch of your idea of the final product.
- List the challenges you see to completing this project.
- Explain the steps to reconstruct your project so that it can be reproduced by anyone.
- What changes would you make to the final design if you had time to redesign?
- Explain why your team chose one design idea over another.

One-Day Camp: A Design Process - From Structures to Rockets

As the day begins, trainees are challenged to imagine what an engineer is and what they do. Throughout the day glimpses into the role of engineers at NASA and experimentation with engineering tasks helps students to gain a full picture of the engineering profession. The concepts of structural engineering are introduced in Spaghetti Anyone? The connection between structural engineering and rocketry are made in the observations of the launch of the new Mars rover then designing and testing rockets.

Title	Overview	Time	Cost	Additional Resources
Engage: Introduction to Engineering				
Journal: Describe or draw what you think an engineer is and what an engineer does.				
NASA for Kids: Intro to Engineering Video	Trainees begin the day by drawing and describing what they think an engineer is and what an engineer does. Next, they can watch this video about engineers at NASA and see if they want to make any modifications to their definition of an engineer and what an engineer does. You might want to consider having students return to this at the end of the day and see if their drawings have changed.	0.5 hrs	$	
Explore: Hands-on Exploration of Structural Engineering				
Spaghetti Anyone?	Using the engineering design process trainees, working in teams, are challenged to build a structure that can handle the greatest load with the limited materials given. Trainees explore various designs and techniques as they build and test the final design. The debriefing process will highlight basic principles of structural engineering such as: compression, tension forces and repetition of geometric patterns to enhance structural integrity.	1.5 hr	$$	Teacher Training Video with demonstrations of building options, debriefing questions and photographs that correspond to the principles introduced here.

Elaborate: From Structures to Rockets				
Journal: Draw a picture of a rocket and describe what happens during a rocket launch. Make changes and additional observations as you watch the launch video.				
Atlas V Launch of Mars Science Lab	As trainees watch this video of the launch of the Mars Science Lab (MSL) Curiosity they can use their observational skills to develop questions and comments about rockets in their journals.	0.5 hrs	$	Making the Connection: A great resource for students is to view the rocket launch pad and discuss the connections between the structural principles they learned and what a rocket needs to launch.
Explore: 3,2,1,Puff				
3,2,1, Puff	This activity from NASA's Rockets Educator Guide will help trainees explore the basic of rocket design using small indoor paper rockets and launch them by blowing through a straw.	1.5 hrs	$	
Explain – Evaluate:				
Ride the Wind: Compressed Air Rocketry	Use the engineering design process to build a structure to handle the greatest load. Trainees will explore various designs and techniques before building and testing the final design (evaluation). Set challenges for distance and/or height of the rockets flight.	2.0 hrs	$$	Tutorial Video for Teachers
Total Hours		6.0 hrs		

Two-Day Camp - Day One: A Design Process - From Structures to Rockets

As the day begins, trainees are challenged to imagine what an engineer is and what they do. Throughout the day glimpses into the role of engineers at NASA and experimentation with engineering tasks helps students to gain a full picture of the engineering profession. The concepts of structural engineering are introduced in Spaghetti Anyone? The connection between structural engineering and rocketry are made in the observations of the launch of the new Mars rover then designing and testing rockets.

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Total Hours		6.0 hrs		

Two-Day Camp - Day Two: Designing a Mission

As trainees return for day two they will be able to apply their discoveries about engineering design, structures and rockets to design missions to Mars and the Moon. To begin to understand how mission goals and environmental constraints can change the design process, trainees will design both a human and robotic mission.

Title	Overview	Time	Cost	Additional Resources
Engage: Launching a Mars Rover				
Journal: List all the information you know about Mars or all the questions you have about Mars.				
Launching a Mars Rover Video	Trainees can begin the day by completing a journal list that has everything they know about Mars. Next they can guess what challenges might exist if they wanted to send a robot to the surface of Mars. Trainees can watch the Launching a Mars Rover video and then compare their guesses with the video.	0.5 hrs	$	
Explore: Mars Image Analysis – Where Are We Going?				
Mars Image Analysis	This activity from the Mars Education team has trainees explore image analysis as a tool to use as a basis for landing site selection.	1.5 hrs	$	Landing Site Selection for Curiosity Mars Odyssey THEMIS Images
Explain: Marsbound				
Marsbound	The goal of this activity is to use the excitement of Mars exploration to engage trainees as they learn about systems engineering design, science, and technology. Combining all they have learned so far, teams will develop a plan to send a rover to Mars.	2.0 hrs	$$	Tutorial Video for Teachers (Please note that Marsbound information is near the end of the video.)

Elaborate: Survival				
Journal: Make a list of everything you would need to survive on the Moon.				
Survival!	Trainees begin to explore how to build on their previous mission learning as they elaborate to now plan a human mission. Groups can then use the Moon Survival items from the Survival activity guide to challenge trainees to select and prioritize items to help them survive on the Moon. Note: This activity was designed to compare the exploration of Jamestown in 1607 with plans for lunar exploration. Expanding this activity to include the historical items is also appropriate if time allows.	1.0 hrs	$	Exploration: Then and Now
Elaborate: Can We Take It With Us?				
Can We Take It With Us? (Pg 27)	Trainees work in teams to determine the maximum amount of payload that they can take on a mission. Trainees are given a container that represents the maximum weight allowed. They are also given a list of mandatory mission ratios, a double balance, 80 pennies, and an empty container to weigh their trial payloads. The team closest to the maximum payload weight without going over is declared the winner.	1.0 hrs	$	
Excite: New Frontiers for NASA: Designing a Crew Exploration Vehicle (CEV)				
Designing a CEV	Trainees will get to work on designing a new vehicle just like NASA is designing and testing models of a possible future spacecraft that will take us back to the Moon, Mars, or an asteroid. This spacecraft is called the Crew Exploration Vehicle (CEV) or more recently, the Space Exploration Vehicle (SEV).	2.0 hrs	$	NASA's Space Exploration Vehicle (SEV)
Total Hours		8.0 hrs		

Weeklong - Day One: A Design Process: From Structures to Rockets

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Total Hours		6.0 hrs		

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Elaborate: Can We Take It With Us?				
Can We Take It With Us? Page 27	Trainees work in teams to determine the maximum amount of payload that they can take on a mission. Trainees are given a container that represents the maximum weight allowed. They are also given a list of mandatory mission ratios, a double balance, 80 pennies, and an empty container to weigh their trial payloads. The team closest to the maximum payload weight without going over is declared the winner.	1.0 hrs	$	
Excite: New Frontiers for NASA: Designing a Crew Exploration Vehicle (CEV)				
Designing a CEV	Trainees will get to work on desiging a new vehicle just like NASA is designing and testing models of a possible future spacecraft that will take us back to the Moonm Mars, or an asteroid. This spacecraft is called the Crew Exploration Vehicle (CEV) or more recently, the Space Exploration Vehicle (SEV).	2.0 hrs	$	NASA's Space Exploration Vehicle (SEV)
Total Hours		8.0 hrs		

Weeklong - Day Three: Humans in Space

On day three, trainees apply the engineering process to meeting the challenges of human space exploration. Starting with an overview of designing a mission to the Moon and then focusing on a critical element of human exploration – water!

Title	Overview	Time	Cost	Additional Resources
Engage: Where and how do astronauts live?				
Journal: As you watch the video, make notes about how astronaut life is similar or different from your daily life.				
At Home on ISS with Scott Kelly	Trainees discover how astronauts live on board the International Space Station (ISS) as they prepare to design habitats for the Moon.	0.5 hrs	$	A Day in the Life Aboard the ISS
Explore: Field Trip to the Moon				
Field Trip to the Moon	Trainees continue with classroom activities that investigate the moon's habitability and sustainable resources. These activities culminate with plans for the design and creation of a lunar station. The trainees are assigned to one of six engineering teams with one of six topics to investigate: ecosystem, geology, habitat, engineering, navigation or medical.	2.5 hrs	$	Field Trip to the Moon Webpage Field Trip to the Moon Informal Educator Guide
Explore: Recycling on the International Space Station (ISS)				
Journal: List all the ways you use water each day and estimate how much water, in gallons, that you use in a day.				
Recycling on the ISS Video (long download)	This NASA eClips – Our World video explains the need to recycle water on board the ISS. Before watching the video, have trainees write in their journals about their daily use of water.	0.5 hrs	$	
Elaborate: Designing a Shower Clock				
Designing a Shower Clock	Trainees think and act like engineers and scientists as they follow the design process to successfully complete a team challenge. Students design, measure, build, test, and re-design a shower clock. Then, students discuss ways to conserve and recycle water.	3.0 hrs	$$	ISS Environmental Control and Life Support System Brain Bites: How Do You Go to the Bathroom in Space?
Total Hours		6.5 hrs		

Weeklong - Day Four: Exploring a Planetary Surface

Day Four is designed to challenge trainees to design, test, and build systems to explore a planetary surface. The reason we explore is to continue to learn – having new ways to gather data helps us learn even more. Landing, decent and entry is a critical and challenging step as we try to get rovers to new surfaces. Trainees will explore other mission critical decisions as they look at how to design a rover that can gather data and determining where to explore.

Title	Overview	Time	Cost	Additional Resources
Engage: Apollo 11 – The First Humans Land on the Moon				
Journal: If you were an astronaut, where would like to be the first human to explore and why?				
Apollo 11 Mission Montage Video	Trainees start the day by imaging themselves as astronauts and journaling about where they want to explore.	0.5 hrs	$	Apollo 11 Videos
Explore: Touchdown				
Touchdown	Trainees start this day of engineering by developing a simple lander to safely place astronauts on the surface of the Moon.	1.0 hrs	$	On the Moon Educator Guide
Explain: Mars Phoenix Lander: Entry, Descent, and Landing				
Entry, Descent and Landing	This video from NASA highlights the challenges of landing on the surface of Mars. Before watching the video, have trainees make journal entries listing challenges to landing on Mars.	0.5 hrs	$	
Elaborate: Landing a Rover				
Landing a Rover	Trainees think and act like engineers and scientists as they follow the design process to successfully complete a team challenge. Within this work, students design, measure, build, test, and re-design a rover and landing system for Moon or Mars.	3.0 hrs	$	Teacher Training Video Part 1 Teacher Training Video Part 2
Evaluate: Moon Rovers				
Moon Rovers	Trainees design and build a rubber band-powered rover that can scramble across the room.	1.5 hrs	$	Teacher Training Video
Total Hours		6.5 hrs		

Weeklong - Day Five: Spacecraft Design

Day Five is designed to challenge trainees to bring together everything they have learned during the camp about the engineering process, structures, mission planning and exploration and apply that to the design and testing of spacecraft models.

Title	Overview	Time	Cost	Additional Resources
Engage - Explore: My Saturn Spacecraft				
My Saturn Spacecraft	Trainees start this day of engineering by developing a simple spacecraft to investigate Saturn and its moons.	2.5 hrs	$	Solar System Exploration: Saturn
Elaborate: How to Keep Gelatin from Melting?				
How to Keep Gelatin from Melting?	Exploring Mercury can be challenging, especially so close to the Sun. In this challenge, trainees will design and build a platform that will be placed on top of a heat source. A 6 cm x 6 cm x 6 cm cube of gelatin will be placed on the platform, with a thermometer inserted in it. The goal is to keep the temperature inside the cube as cool as possible and prevent the gelatin from melting.	2.5 hrs	$	MESSENGER Webpage
Evaluate: Trainee Expo				
Arranged as a poster session, symposium, or an open house, this time allows trainees to share their work through their models, journals, posters, images, videos, and other artifacts with each other, families, and the community. This is also a great time to have a brief ceremony to certify the trainees as Junior Engineers. Allow 2-3 hours for this event.				